

Carbon Steel, Stainless Steel & Non-ferrous Metals

Metals are one of the most commonly used engineering and structural materials. There is an incredible variety of metal types and grades within each type, each with different properties, strengths and weaknesses. Here we will explore for most commonly used metals, their advantages and disadvantages and their applications.

Carbon Steel

What is carbon steel?

Carbon steel, an alloy of iron and carbon, makes up close to 90% of worldwide steel production. In fact, most of the time it is just referred to as “steel” – it’s that ubiquitous.

Carbon steels can have up to 2.1% carbon and are classified according to their carbon content.

- 0.05% to 0.30% carbon – Low carbon steel (mild steel)
- 0.31% to 0.60% carbon – Medium carbon steel
- 0.61% to 1.5% carbon – High carbon steel
- 1.51% to 2.1% carbon – Ultra-high carbon steel

Increasing the carbon content of steel improves its strength, but also makes the steel harder and more brittle. Higher carbon steels are also more difficult to cut, form and weld. As the carbon content of steel increases, so does the cost of the material.

In most cases, “carbon steel” is used to refer to mild steel. All grades of carbon steel can be recycled and most are magnetic.

Where is carbon steel most commonly used and why?

Mild steel is the bread and butter of the engineering world. It’s strength, malleability and relatively low cost make it suitable for a wide variety of applications – from manufacturing components to construction materials to pipelines. There are very few industries where mild steel does not make an appearance.

Medium carbon steel has higher strength and resistance to wear than carbon steel, but is more difficult to shape and more expensive. It is used in demanding applications such as railroad axles, gears and wheels or large structural beams.

High carbon and ultra-high carbon steel are the most expensive of the carbon steels. They are incredibly strong and hard but very difficult to work. These steels are primarily used for metal and woodcutting components, such as drill bits and saw blades.

What are the weaknesses of carbon steel?

Each of the carbon steels has slightly different weaknesses. Mild steel is too soft and ductile for many applications and wears poorly, while the higher carbon steels are hard to work and prone to shattering.

Steel, while strong relative to its weight, is a dense and heavy material – large quantities of steel quickly pack on pounds to a project. Additionally, all carbon steels are vulnerable to corrosion (rust) and suffer in wet and humid environments. However, carbon steels can be treated with protective coatings or painted to improve their corrosion resistance.

Stainless Steel

What is stainless steel?

Stainless steel is similar to carbon steel in that it is also an alloy of iron and carbon. However, it also contains 10.5% to 26% chromium. This chromium content causes the exposed surface of the metal to form a thin layer of chromium oxide, which protects against corrosion. If this chromium oxide layer is damaged, the exposed stainless steel immediately forms a new protective layer.

There are several different grades of stainless steel based on carbon content, chromium content and inclusion of other alloying elements such as nickel, molybdenum, nitrogen and manganese (among many others). The different grades of stainless steel vary according to their strength, heat resistance, formability and corrosion resistance. Stainless steel can also be easily recycled.

Where is stainless steel most commonly used and why?

Whereas standard carbon steel is vulnerable to rust when exposed to air and moisture, stainless steel is highly corrosion resistant. It can easily be cleaned or sterilized and is non-reactive in contact with most products. This makes standard stainless steel a great choice for food processing applications, kitchenware, transportation of chemicals and the medical industry. Some grades of stainless steel are specially formulated to resist corrosion from seawater and toxic chemicals.

Another benefit of stainless steel is its attractive appearance. With similar strength (depending on the grade) to carbon steel, it is frequently used in construction as its surface

will stay shiny and rust-free with very little maintenance. The most commonly used grades of stainless steel can be welded or worked nearly as easily as carbon steel.

What are the weaknesses of stainless steel?

Stainless steel is significantly more expensive than carbon steel of similar strength. The cost of both carbon and stainless steel will vary significantly based on their grade, however as a rule of thumb stainless steel can cost 3 to 6 times as much as an equivalent carbon steel.

Aside from the increased cost, stainless steel suffers from many of the same weaknesses as carbon steel. It is heavy and dense, low-carbon grades are soft and ductile while high-carbon grades are brittle and hard to work with.

Non-ferrous Metals

What are non-ferrous metals?

Non-ferrous metals simply refer to metals that do not contain any iron. The vast majority of metal production – 90% – involves ferrous metals like iron, carbon steel and stainless steel. Some common non-ferrous materials are:

- Aluminium
- Titanium
- Zinc
- Copper and its alloys (bronze, brass)
- Silver, Gold and Platinum (precious metals)
- Nickel

Ferrous metals are used worldwide for their strength, workability and low cost, but they are also dense, ductile and vulnerable to corrosion. Non-ferrous materials are generally chosen for their special attributes.

Where are non-ferrous metals most commonly used and why?

Non-ferrous metals are used in many different industries and applications. Here are the ones you are most likely to encounter:

Aluminium: Extremely strong for its weight, aluminium is used in applications where steel is too heavy. It also has excellent corrosion resistance. It is frequently used in aerospace engineering.

Titanium: Extremely strong and stiff for its weight. Excellent corrosion resistance including against chemicals and seawater. Also frequently used in aerospace applications.

Copper and alloys: Copper is highly electrically and thermally conductive. It is also ductile and malleable, very easy to form. It is commonly used in electrical applications and wires. Its most common alloys, bronze and brass, are also conductive but stronger and more durable.

What are the weaknesses of non-ferrous metals?

The weaknesses of non-ferrous materials are as varied as their strengths. They are generally significantly more expensive than ferrous metals, which means they are only selected when their unique attributes are necessary to the application. Most are non-magnetic.

Aluminium: Expensive, non-magnetic, difficult to weld, can be abrasive to tools during forming/cutting. Not suitable for high (> 175 C) temperatures.

Titanium: Very expensive, difficult and expensive to mine, difficult and expensive to work and weld. Not suitable for very high (> 400 C) temperatures.

Copper and alloys: Their ductility also makes them soft and unsuitable for high strength applications. Both copper and its alloys are vulnerable to corrosion.